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Western Spruce Budworm

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The western spruce budworm, *Choristoneura occidentalis* Freeman, is the most widely distributed and destructive defoliator of coniferous forests in Western North America. It is one of nearly a dozen *Choristoneura* species, subspecies, or forms, with a complexity of variation among populations found throughout much of the United States and Canada. It occurs in the Rocky Mountains from Arizona and New Mexico northward into Colorado, Utah, Wyoming, Montana, and Idaho; in the Pacific Northwest in Oregon and Washington; and in British Columbia and Alberta, Canada (fig. 1).

The first recorded western spruce budworm outbreak was in 1909 on the southeastern part of Vancouver Island in British Columbia, Canada. Since that year, infestations of this and related species frequently have been reported in western Canada.

The budworm was first reported in the United States in 1914 in Oregon; however, it was not recognized as a serious threat to western coniferous

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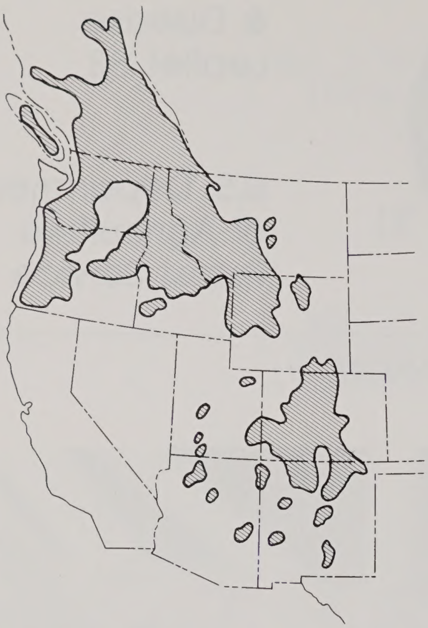

Figure 1.—*Geographic distribution of the western spruce budworm in Western United States and Canada.*

forests until 1922, when two outbreaks were reported near Priest Lake in northern Idaho. Subsequent widespread and destructive outbreaks in the Rocky Mountains and in the Pacific Northwest have caused topkilling, serious economic losses in tree growth, and some tree mortality primarily in regeneration, sapling, and pole-sized trees.

No typical pattern or trend in western spruce budworm epidemics has been apparent; most of the early epidemics lasted for a few years and then subsided naturally; others persisted longer, at times without spreading over large areas. An epidemic in the northern Rocky Mountains, which began in 1949, has now persisted for more than 30 years, in spite of repeated insecticidal treatment between 1952 and 1966 of more than 6,000,000 acres (2,430,000 ha) of forests. Some smaller epidemics in the southern and central Rockies were apparently terminated by aerial spraying; others subsided naturally.

Description

Adult moths (fig. 2) are about ½ inch (12.7 mm) long and have a wingspread of ⅞ to 1⅛ inches (22 to 28 mm). Moths of both sexes are similar in appearance, although the females are a bit more robust than males. Both sexes fly. The gray- or orange-brown forewings are banded or streaked, and each usually has a conspicuous white dot on the wing margin. Eggs are oval, light green, and about ³⁄₆₄ inch (1.2 mm) long and overlap like shingles (fig. 3).

Larvae develop through six stages. Newly hatched larvae are yellow-green with brown heads. In the next three stages, larvae have black heads and collars and orange- or cinnamon-brown bodies (fig. 4). In the fifth stage, larvae have reddish-brown heads marked with black triangles, black collars, and pale olive-brown

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Figure 2.—*An adult male western spruce budworm and the empty pupal case from which he has just emerged.*

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Figure 3.—*Egg mass of the western spruce budworm laid on Douglas-fir needle.*

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Figure 4.—*Fourth-stage western spruce budworm larva feeding on Douglas-fir needles.*

bodies marked with small whitish spots. Mature larvae (see cover) are 1 to 1¼ inches (25 to 32 mm) long, with tan or light chestnut-brown heads and collars and olive- or reddish-brown bodies with large ivory-colored areas. Pupae are ½ to ⅝ inch (13 to 16 mm) long, broad at the head end, and narrower toward the tail. They are brownish-yellow or brownish-green at first, and later turn reddish-brown (fig. 5).

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Figure 5.—*Female pupa of the western spruce budworm spun among dead needles and larval frass and webbing.*

Life History

Throughout most of its range, the western spruce budworm completes one cycle of development from egg to adult within 12 months. Moths emerge from pupal cases usually in late July or early August; in the southern Rockies, adults often begin emerging in early July. The adults mate, and within 7 to 10 days, the female deposits her eggs and then dies.

Each female deposits approximately 150 eggs, usually on the underside of conifer needles. Eggs are laid in one- to three-row masses containing a few to 130 eggs, with an average of 25 to 40 eggs per mass. Females usually lay

some eggs at the site where they emerge and mate, then disperse to deposit their remaining eggs.

Larvae hatch from eggs in about 10 days. Larvae do not feed, but seek sheltered places under bark scales or in and among lichens on the tree bole or limbs. Here, they spin silken tents called "hibernacula" in which they remain inactive through the winter.

In early May to late June, larvae leave their hibernacula to search for food. They first mine or tunnel into year-old needles, closed buds, or newly developing vegetative or reproductive buds. Larvae usually leave traces of silken webbing and bits of excrement at the feeding site or entrance hole (fig. 6). As new shoots flush, larvae spin loose webs among the needles and feed on the new foliage. As shoots continue to elongate and needles develop, adjacent shoots often are webbed together by the larvae and begin to appear twisted or stunted. New foliage, which is normally the preferred food, is usually entirely consumed or destroyed before larvae will feed on older needles. On some hosts, larvae favor developing male flowers and conelets as food, and on western larch, larvae mine and sever the terminal and lateral shoots.

Larvae become full grown usually in early July about 30 to 40 days after leaving their overwintering sites. As larvae mature, the webbed branch tips on which they have fed begin to turn reddish brown (fig. 7). Larvae pupate in webs of silk they have spun either at the last feeding site or elsewhere on the tree. The pupal stage usually lasts about 10 days.

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Figure 6.—*Douglas-fir bud mined by third-stage western spruce budworm larva. Note larval webbing and frass at entrance hole.*

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Figure 7.—*Douglas-fir needles, fed on and webbed together by western spruce budworm larvae, turn reddish brown in early July.*

Host Trees

The most common host-tree species of the western spruce budworm are: Douglas-fir (*Pseudotsuga menziesi* (Mirb.) Franco), grand fir

(*Abies grandis* (Doug. ex D. Don) Lindl.), white fir (*Abies concolor* (Gord. and Glend.) Lindl. ex Hildebr.), subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), corkbark fir (*Abies lasiocarpa* var. *arizonica* (Merriam) Lemm.), blue spruce (*Picea pungens* Engelm.), Engelmann spruce (*Picea engelmannii* Parry ex Engelm.), white spruce (*Picea glauca* (Moench) Voss), and western larch (*Larix occidentalis* Nutt.). Larvae feed occasionally on Pacific silver fir (*Abies amabilis* Dougl. ex Forbes), mountain hemlock (*Tsuga mertensiana* (Bong.) Carr.), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), lodgepole pine (*Pinus contorta* var. *latifolia* Englem.), ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), western white pine (*Pinus monticola* Dougl. ex D. Don), limber pine (*Pinus flexilis* James), and whitebark pine (*Pinus albicaulis* Engelm.). Some of these tree species are also hosts of other closely related species of *Choristoneura* whose populations sometimes occur simultaneously with the western spruce budworm.

Often budworm larvae feed on and seriously damage coniferous trees that are planted as ornamentals, such as Norway spruce (*Picea Abies* (L.) Karst., and Scotch pine (*Pinus sylvestris* L.).

Damage

Cones and seeds.—In addition to foliage, budworm larvae feed heavily on staminate flowers and developing cones of host trees (fig. 8). The resultant decline in seed production has a serious impact in seed orchards, seed production areas, and forest sites that are difficult to regenerate naturally. Moreover, artificial regeneration practices are affected because seed is not available for nurseries or direct seeding.

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Figure 8.—*A newly developing western larch cone destroyed by a western spruce budworm larva.*

Unlike some cone and seed insects, budworm larvae do not always restrict their feeding to a single cone. Often, second- or third-stage larvae feed on newly developing conelets that soon shrivel up, dry out, and fall from the tree. As these cones dry out and become unsuitable for food, larvae continue feeding on other cones or on foliage.

In some Douglas-fir stands, nearly all cones may be damaged or destroyed by feeding larvae, especially when larval population densities are high and cone crops are light. Top-killing of some host trees, as a result of persistent heavy defoliation, often

precludes cone production for many years, even when budworm populations subside.

Regeneration.—The budworm also seriously affects regeneration—host trees usually less than 5 feet (1.5 m) tall and 1 to 2 inches (2.5 to 5.0 cm) in diameter. These young trees are especially vulnerable when growing beneath mature trees, since larvae disperse from the overstory and feed on the small trees below. Coniferous seedlings have relatively few needles and shoots and can be seriously deformed or killed by only a few larvae.

Seedling damage or mortality, coupled with the impact of larvae feeding on seeds and cones, can significantly delay the establishment of natural regeneration of host-tree species. Newly established seedlings are particularly vulnerable to being seriously damaged or killed by larvae, particularly when partial cutting methods leave host-tree species in the residual overstory stand. At times, however, very small seedlings are not seriously damaged or killed, probably because many larvae dispersing to the forest floor are eaten by insect and small mammal predators.

Young stands.—As with regeneration, young stands are particularly vulnerable when growing beneath a canopy of overstory trees. In stands of Douglas-fir, true firs, and spruce, after 3 or more years of sustained larval feeding, many trees are almost entirely defoliated, and diameter and height growths are sharply reduced. Some trees are top-killed, which often results in stem deformity, multiple leaders, or the death of the entire tree. In young western larch stands, sustained larval feeding and severance of new shoots causes top deformity and can reduce height growth by as much as 25 to 30 percent. Severe defoliation and top-killing predispose young trees to secondary insects and wood-decaying fungi.

Mature stands.—The greatest impact from budworm defoliation in mature stands is reduced growth, although repeated defoliation sometimes results in top-killing (fig. 9) and tree mortality. Recent studies in

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Figure 9.—*Mature subalpine fir top-killed by the western spruce budworm.*

Idaho and Washington showed that radial growth of defoliated trees declined about 25 percent over a 5-year period, while radial growth of undefoliated, nonhost trees in the

same stands declined only 2 percent. At times, larger, dominant trees are severely defoliated and top-killed, but do not die because the trees produce adventitious foliage throughout the length of the crown, allowing the trees to survive (fig. 10).

In some mature stands, trees severely defoliated by the western spruce budworm may be predisposed to one or more species of tree-killing bark beetles, mainly the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins, and the fir engraver beetle, *Scolytus ventralis* LeConte.

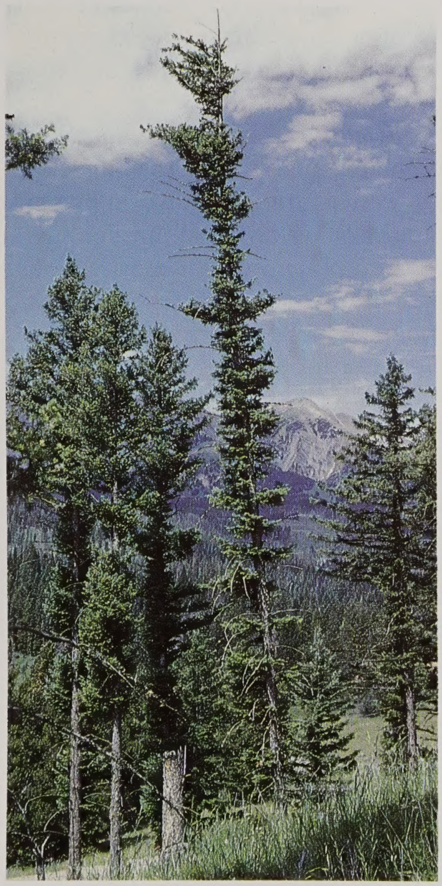

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Figure 10.—*Severely defoliated and top-killed mature Douglas-fir produced adventitious branching throughout length of crown.*

Natural Regulating Factors

Budworm populations are usually regulated by combinations of several natural factors such as insect parasites, vertebrate and invertebrate predators, and adverse weather conditions. However, the combined effect of natural agents does not prevent or reduce population resurgences when climatic and forest stand conditions are favorable for an increase in budworm populations. During prolonged outbreaks when stands become heavily defoliated, starvation can be an important mortality factor in regulating populations.

Western spruce budworm larvae, pupae, and adults are parasitized and preyed upon by several groups of insects and other arthropods, small mammals, and birds. There are more than 40 species of insect parasites (small wasps and flies) of the western spruce budworm, of which four or five species are most common. Spiders, ants, snakeflies, true bugs, and larvae of certain beetles feed on the budworm, as do chipmunks and squirrels. Birds known to feed on the budworm include grosbeaks, warblers, thrushes, sparrows, flycatchers, tanagers, siskins, and waxwings. These natural enemies are probably responsible for considerable mortality when budworm populations are low, but seldom have a regulating influence when populations are in epidemic proportions.

Western spruce budworm larvae are infected by several types of pathogens, but none appear to have a significant effect in regulating populations.

Climatic conditions may adversely affect the budworm in several ways. Small larvae may be blown from the

host tree to the ground when windy conditions exist at the time larvae are hatching or dispersing from their overwintering sites. Cool summer weather retards feeding and development, increasing the time larvae are vulnerable to parasites and predators. Occasionally, larvae have not emerged from eggs before the first freezing temperatures in the fall.

Western spruce budworm larvae established in hibernacula are not affected by extremely low temperatures. A 7-day cold wave, $-43°$ F to $-53°$ F ($-42°$ C to $-47°$ C) in Montana between November 11 and 17, 1959, had little to no effect on overwintering larvae. However, unseasonably low temperatures in the late spring or early summer can kill larvae directly by freezing or indirectly by starvation when their food supply—buds and foliage—is destroyed.

Management

Chemical insecticides.—When necessary, western spruce budworm populations can be substantially reduced with insecticides. Large forested areas can be aerially sprayed for short-term protection, and individual trees can be sprayed using ground equipment.

Chemicals currently registered for use against the budworm include malathion, carbaryl, and acephate. If spraying is needed, State or Federal insect management specialists should be consulted for treatment timing, formulations, dosages, and the most current information on registered insecticides.

Microbial insecticides.—A microbial insecticide registered for use against spruce budworms is the bacterium *Bacillus thuringiensis,* a naturally occurring, host-specific pathogen that affects only the larvae of lepidopterous insects. It is environmentally safe to use in sensitive areas such as campgrounds or along rivers or streams where it may not be desirable to use chemical insecticides. Users should contact State or Federal insect management specialists regarding formulations, dosages, and timing of treatment.

Silviculture.—Little research has been done on reducing the impact of the western spruce budworm by manipulation of the forest through silvicultural practices. The most serious damage, in young forests at least, occurs in relatively pure stands of Douglas-fir or stands with an admixture of true firs and Douglas-fir. Hence, the susceptibility of some forests may be minimized by increasing the complement of nonhost species such as lodgepole pine or ponderosa pine, and reducing the percentage of Douglas-fir and true firs. Managing budworm infestations by silviculture, however, is not practical in many western forests.

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If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S Environmental Protection Agency, consult your local forest pathologist, county agriculture agent, or State extension specialist to be sure the intended use is still registered.

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